Natural Gas Storage in Basalt Aquifers of the Columbia Basin: Hydrogeologic Considerations

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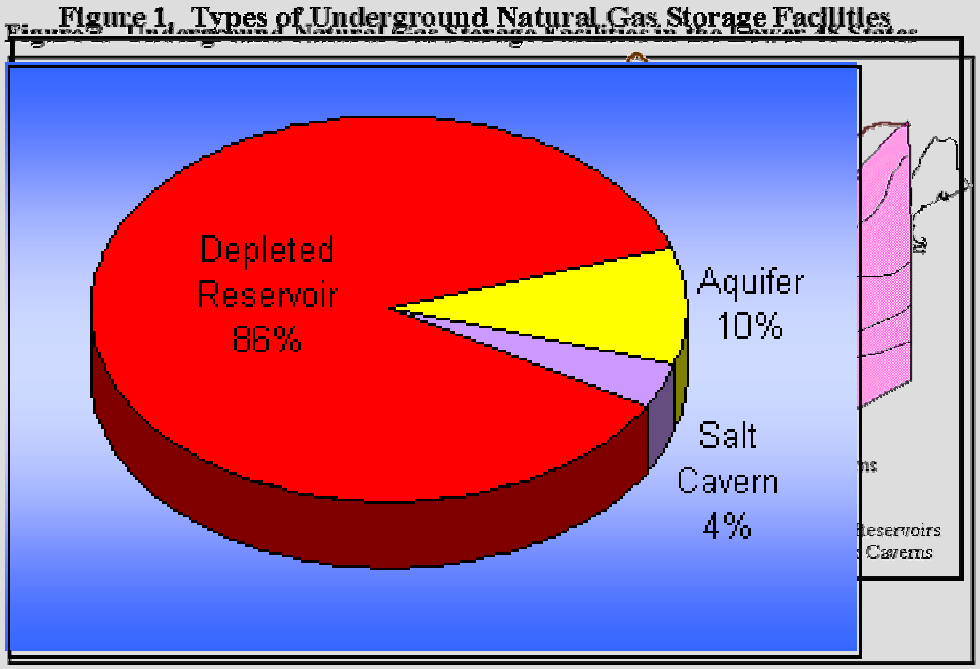
Presentation Outline

- Subsurface Natural Gas Storage
- Columbia River Basalt Group
  - Physical Description
  - Favorable Characteristics
- Hydrogeologic Considerations
  - Site Selection Aspects
  - Storage Zone Issues

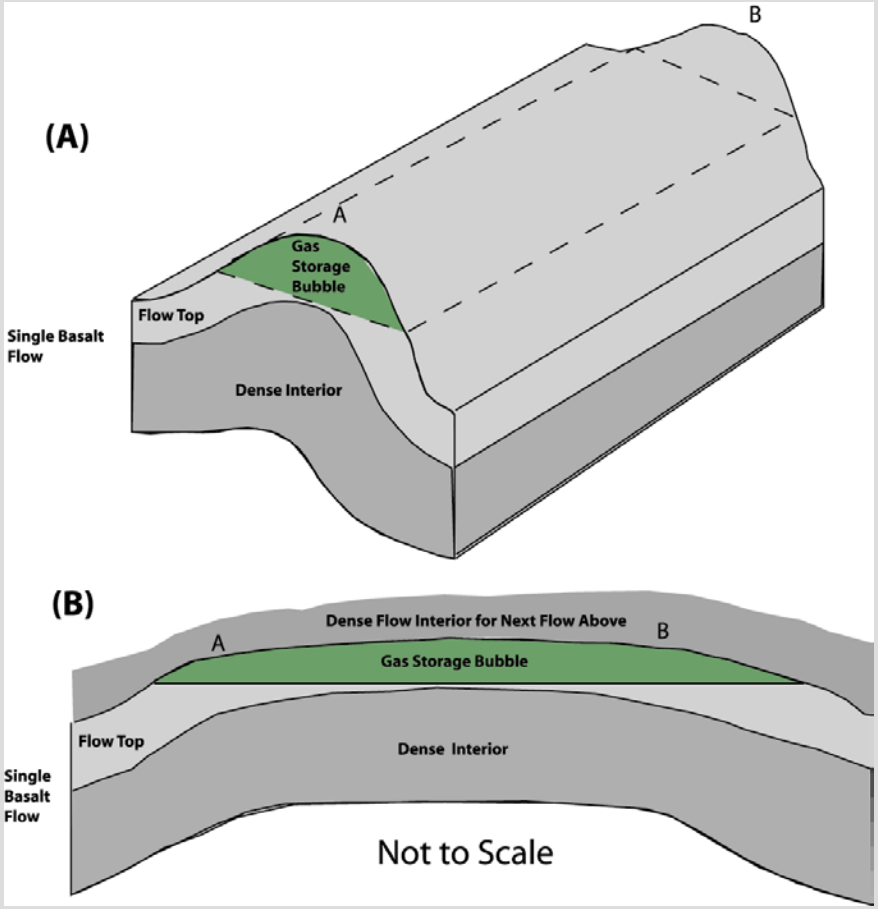
Underground Natural Gas Storage Sites

- Depleted hydrocarbon reservoirs
- Salt cavern structures
- Aquifer storage

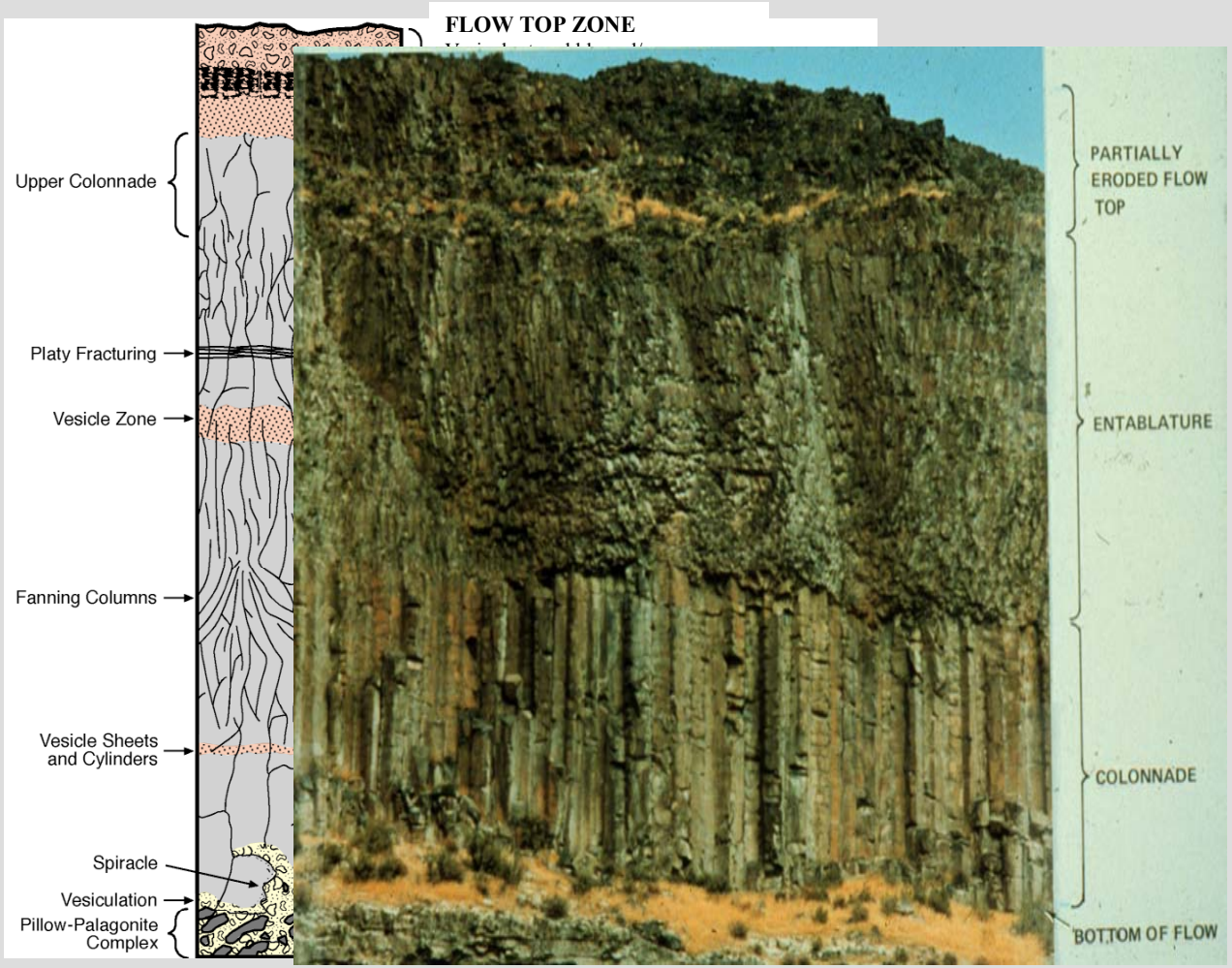


Natural Gas Storage Within Basalt Aquifers Storage Anticlinal Structures

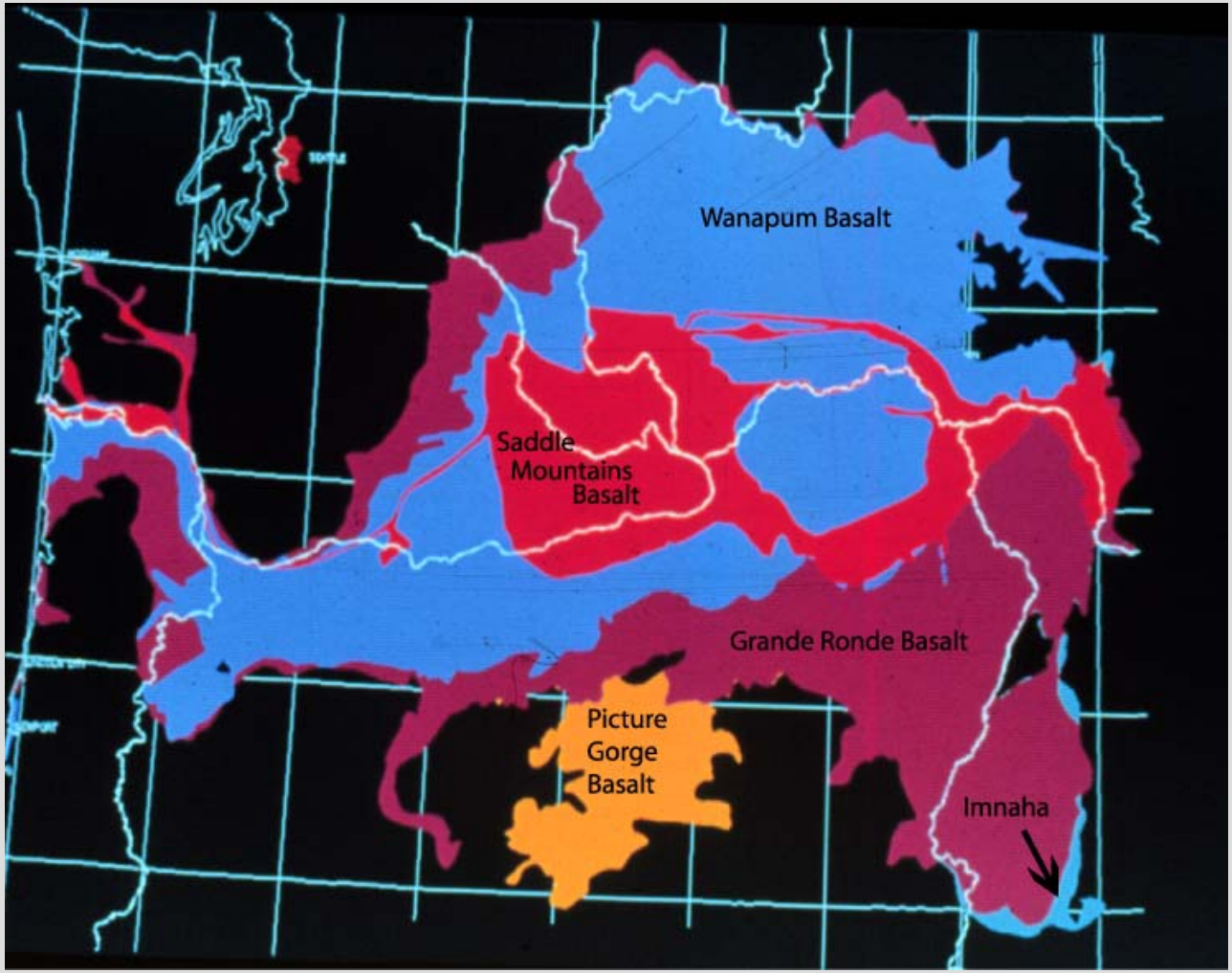
- Reservoir Types
  - Folded/faulted structural traps
  - Hydrodynamic entrapment



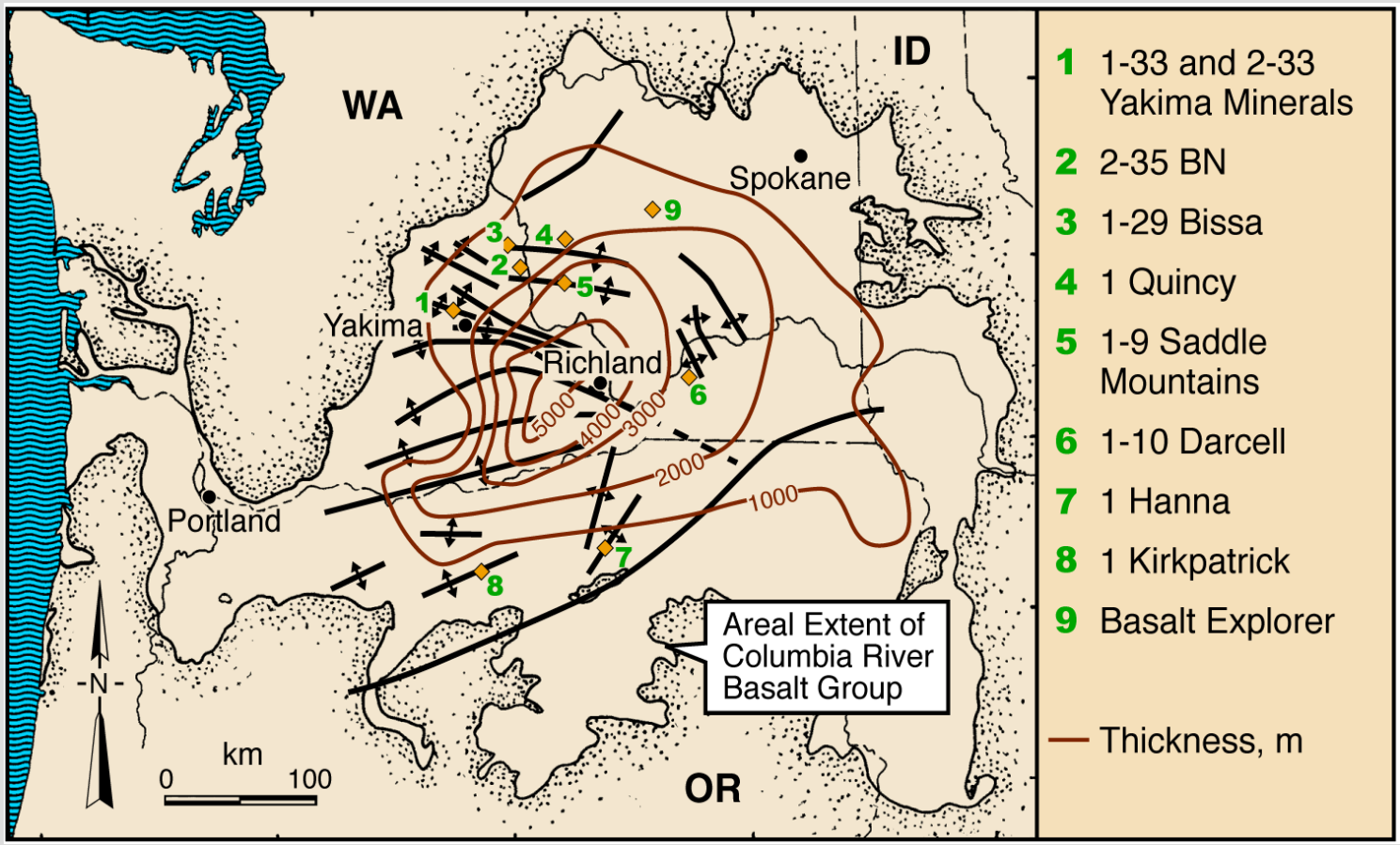
Characteristic Basalt Flow Features



Columbia River Basalt Group Distribution Map



CRBG Major Structure and Thickness Map

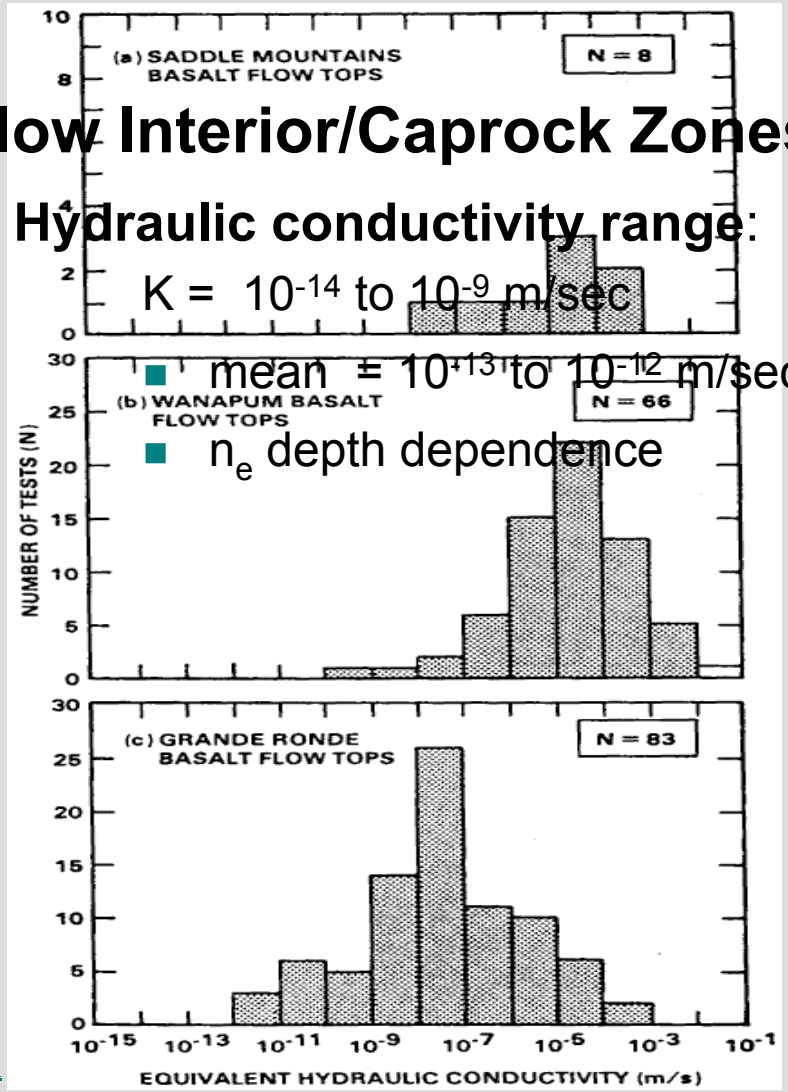


Columbia River Basalts

Favorable Characteristics

- Sufficient thickness and areal extent
- Structural/stratigraphic closure
- Hydraulic/storage properties
- Low groundwater flow rate
- Existing natural gas field
- Regional groundwater flow separation

CRBG Favorable Characteristics - Hydraulic/Storage Properties



Flow Interior/Caprock Zones

Hydraulic conductivity range:

K = 10^{-14} to 10^{-9} m/sec

- mean = 10^{-13} to 10^{-12} m/sec
- n_e depth dependence

Interflow Zones

Hydraulic conductivity range

K = 10^{-2} to 10^{-12} m/sec

- K depth dependence
- K lateral variability

Interflow Zones

Effective porosity range:

n_e = 1 to 25%

- n_e depth dependence
- n_e homogeneity (?)

CRBG Favorable Characteristics - Low Groundwater-Flow Rate

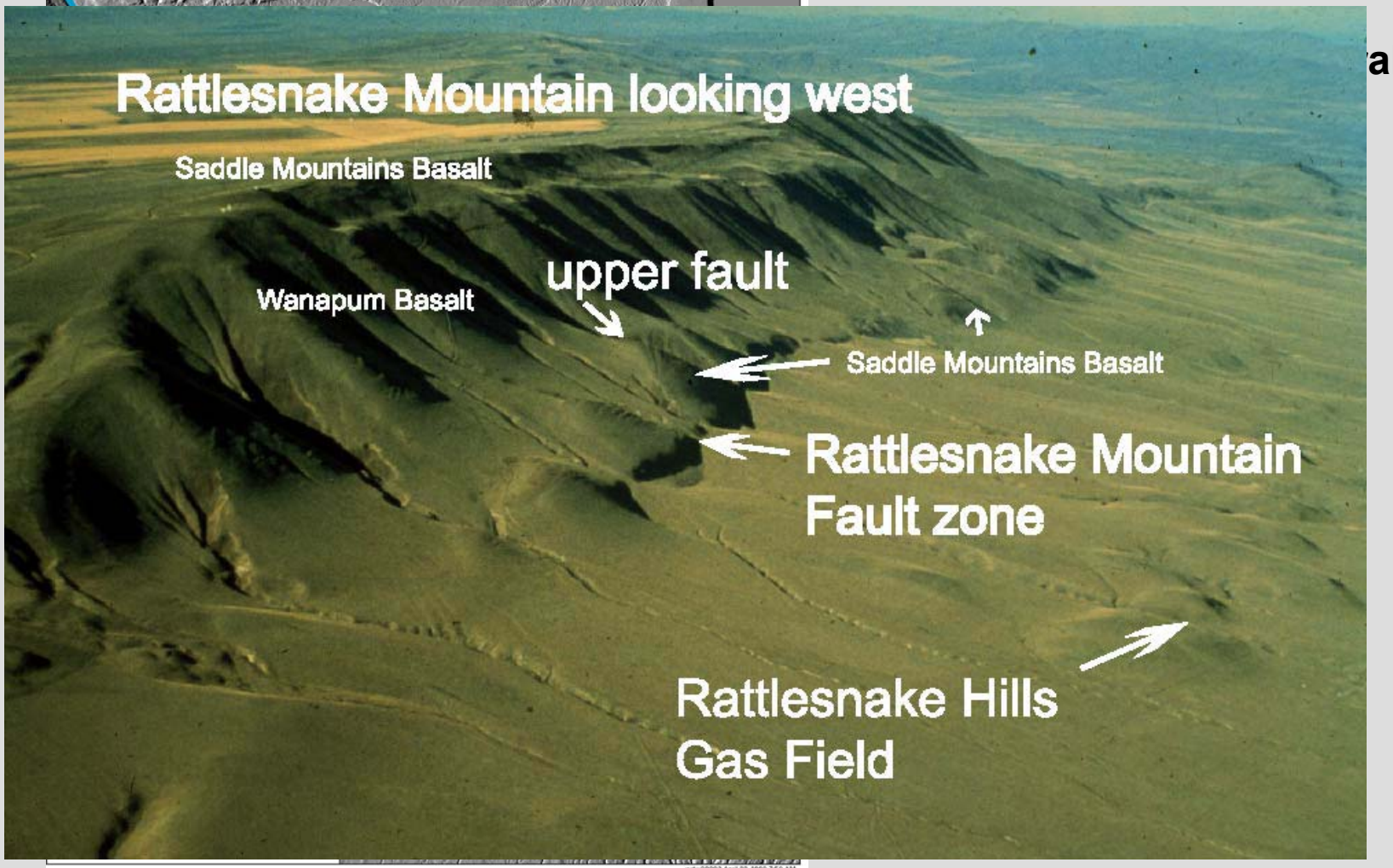
Groundwater-Flow Velocity Determination:

- Isotopic analyses
- Darcy flow rate determination

Results

- Shallow basalt formations: ≤ 3 m/year
- Deep basalt formations: ≤ 1 m/year

CRBG Favorable Characteristics - Occurrence of Natural Gas Field



Groundwater-Flow Separation/Vertical Isolation

Hydrochemical Parameters

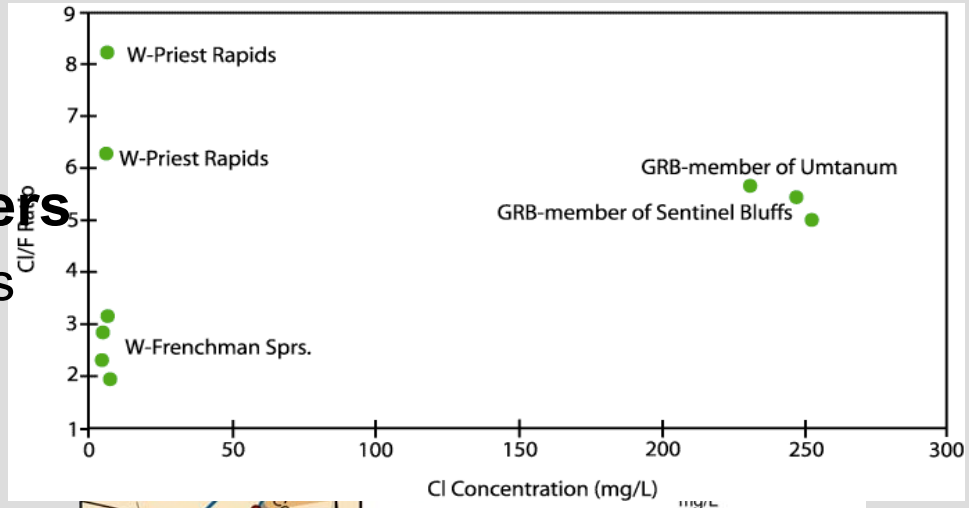
- Major and trace inorganics
- Isotopes
- Gases

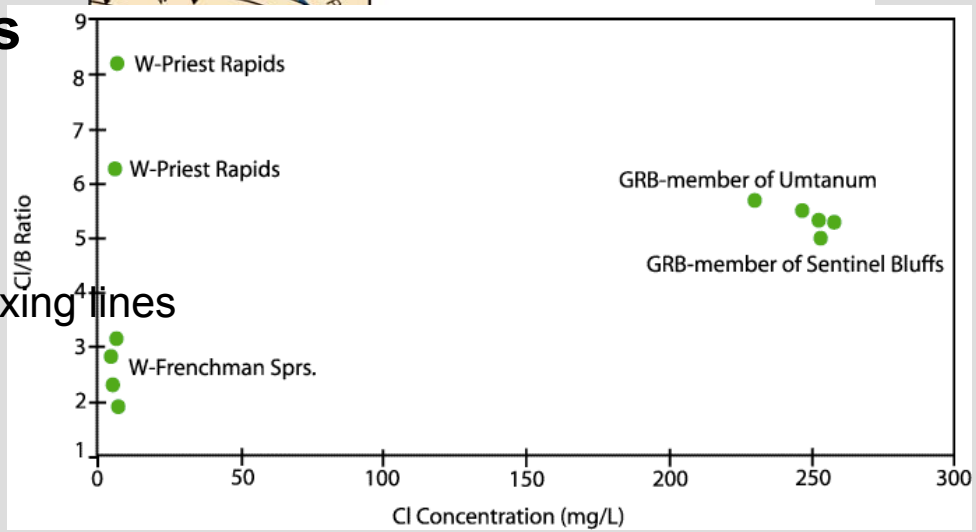
Hydrochemical Ratio Plots

Depth Profile Plots

Hydrochemical Indicators

- Depth Profile Plots
- Ratio Plots
  - Isolation: sharp breaks
  - Communication: gradational mixing lines





Groundwater-Flow Separation/Vertical Isolation

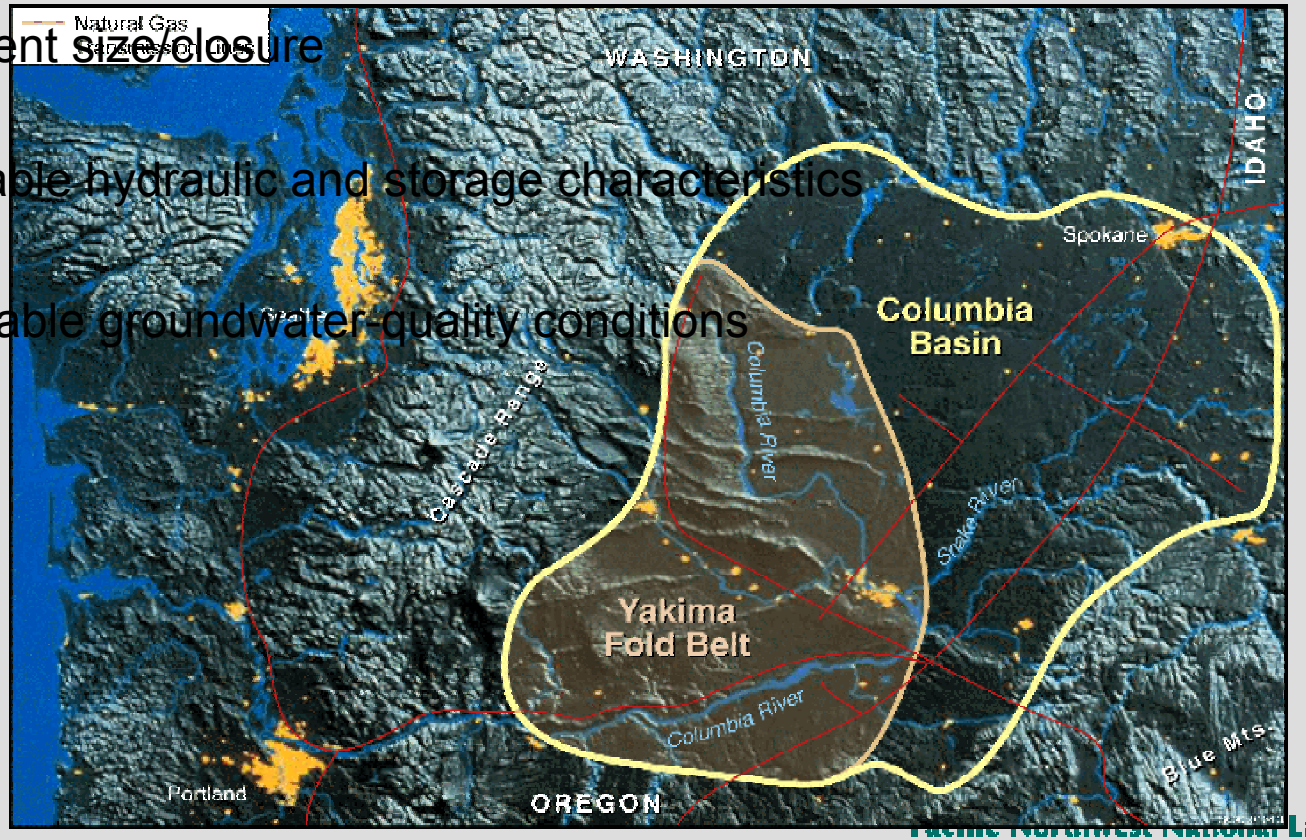
Factors Conducive to Isolation

- Presence of Low-K sedimentary interbeds and saprolite layers
- Presence of thick, dense basalt flow interiors
- Increased depth/effective stress
- Secondary mineral formation

Hydrogeologic Considerations - Site Selection

Aspects

- Proximity to natural gas transmission lines
- Sufficient size/closure
- Favorable hydraulic and storage characteristics
- Favorable groundwater quality conditions



Hydrogeologic Considerations - Site Selection: Favorable Storage Zone Characteristics

Flow Characteristics:

- Flow thickness ≥ 30 m
- Laterally extensive over project area

- **Interflow Zone**
  - Thickness ≥ 10 m
  - K ≥ $5x10^{-6}$ m/sec (≥ 0.5 darcy)
  - n_e ≥ 15%

Closure

- Vertical relief: ≥ 50 m at reservoir depths

Hydrogeologic Considerations - Site Selection: Favorable Caprock Characteristics

Flow Interior/Caprock Zones

- $K \leq 10^{-11}$ m/sec (~1 μdarcy)
- High gas threshold pressure
- Laterally extensive over project area

Hydrogeologic Considerations - Site Selection: Favorable Groundwater Quality Conditions

- Interflow zones having non-potable groundwater
  - High chloride
  - High fluoride
  - Absence of H_2S

Hydrogeologic Considerations - Site Selection: Storage Zone Size Example

Anticlinal Fold

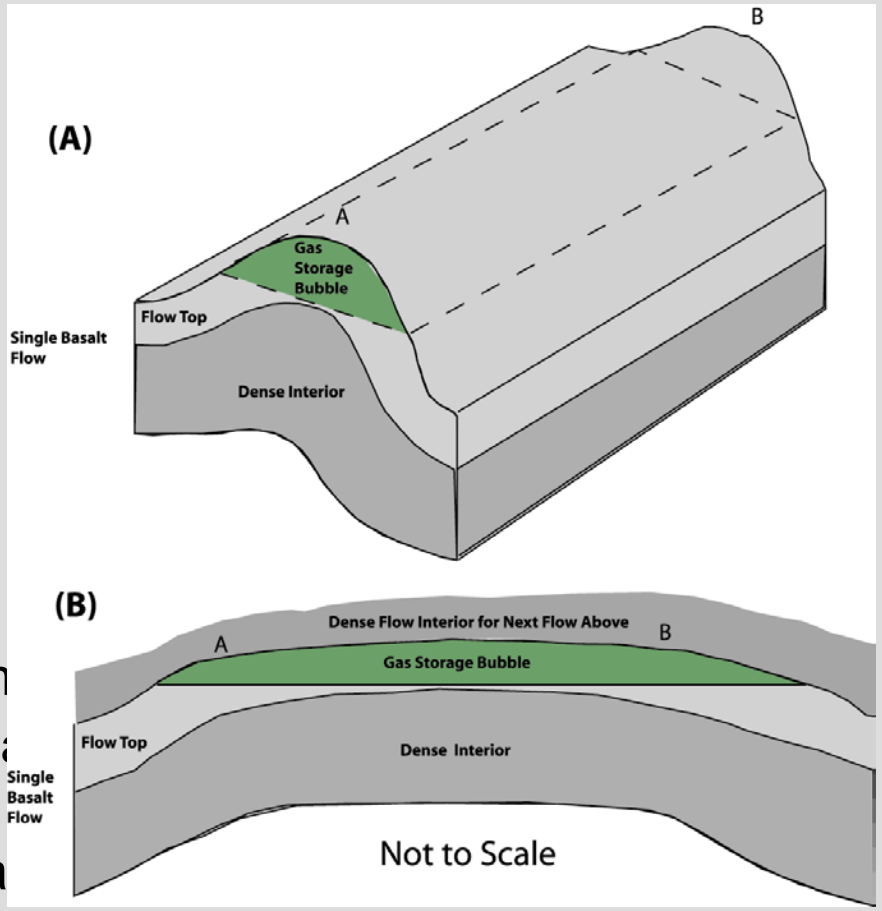
- Area = 7.5 km^2
  (W = 1.5 km, L = 5 km)

Interflow Zone

- Thickness = 10 m
  n_e = 15%

Potential Storage Volume

- Natural gas volume = 400 m
  (depth/pressure = 1000 m/100 a
- Calculated subsurface area



Summary

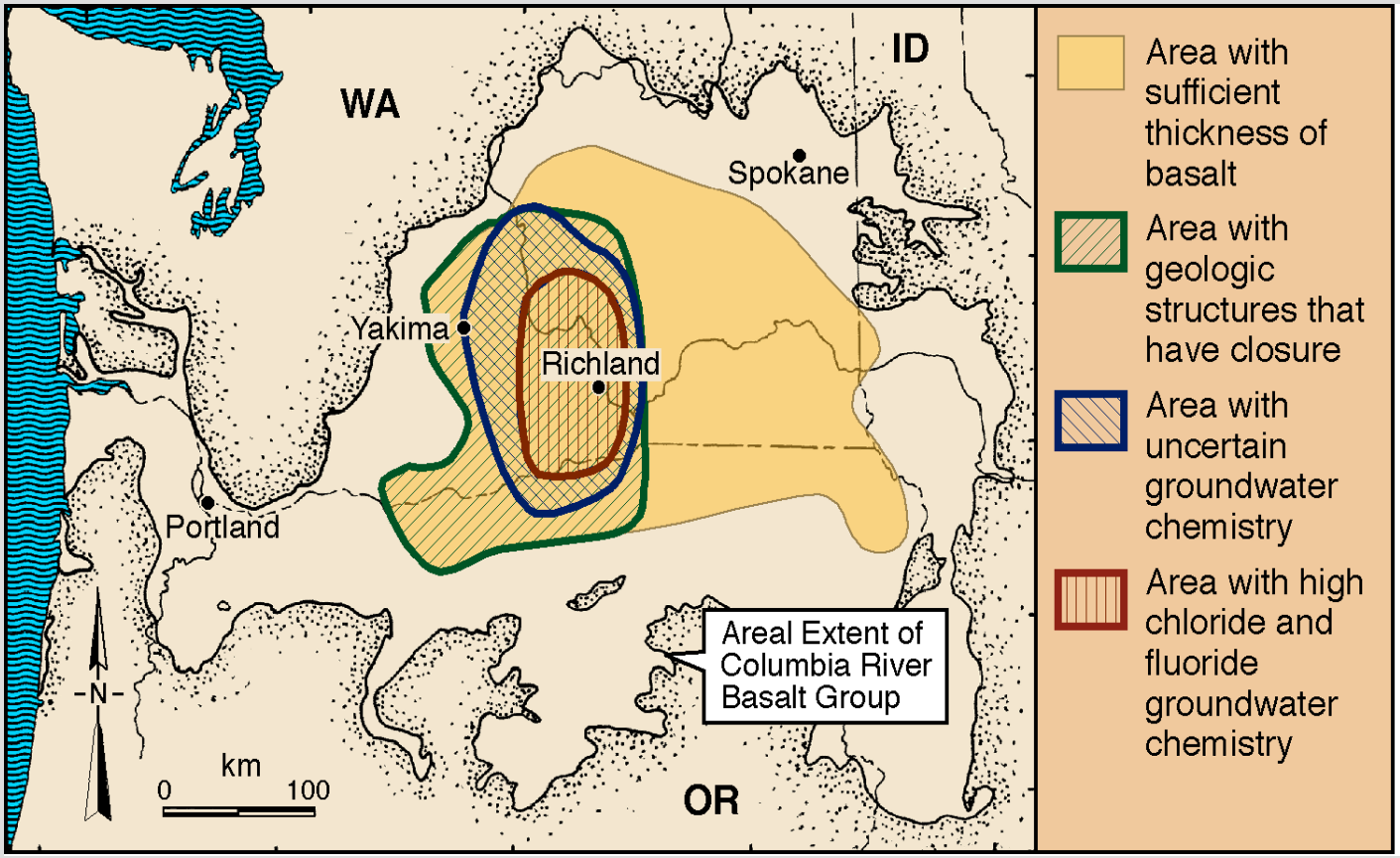
Best Candidates for Natural Gas Storage:

- **Grande Ronde Basalt**
- **Central portion of the Columbia Basin/ Yakima Fold Belt**

This is attributed to favorable:

- **Depth and thickness conditions**
- **Regional hydrostratigraphic isolation layers**
- **Non-potable water-quality conditions**
- **Proximity to surface, natural gas supply lines**

Hydrogeologic Considerations - Site Selection: Favorability Areas For Natural Gas Storage



Reference Report

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